Navy Personnel Research and Development Center
San Diego, California 92152-7250 TN-96-33 March 1996

An Approach to Measurement of Quality and Productivity for Gain Sharing:
Measuring Total Organizational Value

Delbert M. Nebeker
B. Charles Tatum

NPRDC-TN-96-33 March 1996

An Approach to Measurement of Quality and Productivity for Gain Sharing: Measuring Total Organizational Value

Delbert M. Nebeker
B. Charles Tatum

Reviewed, approved, and released
Kathleen E. Moreno
Director
Personnel and Organizational Assessment

Navy Personnel Research and Development Center
53335 Ryan Road
San Diego, CA 92152-7250

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATE COVERED
	March 1996	Final—1 Oct 1992-30 Sep 1993

4. TITLE AND SUBTITLE
An Approach to Measurement of Quality and Productivity for Gain Sharing: Measuring Total Organizational Value

5. FUNDING NUMBERS
Project Element: Reimbursable
Work Unit: 0605104D.000.000

6. AUTHOR(S)
Delbert M. Nebeker, B. Charles Tatum

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Navy Personnel Research and Development Center
53335 Ryne Road
San Diego, CA 92152-7250

8. PERFORMING ORGANIZATION REPORT NUMBER
NPRDC-TN-96-33

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of the Under Secretary of Defense (P&R)
Defense Civilian Personnel Management Services
Work Force Quality and Productivity Division
2461 Eisenhower, Suite 132
Alexandria, VA 22331

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Functional Area: Organizational Assessment
Product Line: Incentive Systems
Effort: Productivity Gains

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE
A

13. ABSTRACT *(Maximum 200 words)*

When measuring organizational effectiveness, the focus should be on the value of what the organization does. The approach described in this report integrates measures of productivity, quality, and other less tangible dimensions of performance into a formula that produces an index of "total value." This index can then be used to assess improvements and make Productivity Gain Sharing payouts.

14. SUBJECT TERMS
Organizational effectiveness, productivity gain sharing (PGS), total quality management (TQM), performance indicators, performance measurement, organizational performance

15. NUMBER OF PAGES
12

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED

Foreword

This report describes an approach to measuring total organizational effectiveness that focuses on the *value* of what an organization does. The approach integrates measures of productivity, quality, and other less tangible dimensions of performance into a formula that produces an index of "total value." Once this total value is determined, it can be used as the basis for a gain sharing payout, or as an index of improvements in total quality.

This report is one of a series of reports on measurement issues related to productivity gain sharing and total quality. The other reports in this series are: (a) *Using Performance Indexing to Measure Organizational Gains in a White Collar Environment* (Tatum & Nebeker, 1996), (b) *Examples of White Collar Measurement Using a Typology of Organizational Effectiveness* (Nebeker, Tatum, & Wolosin, 1996), and (c) *Integrating Measurement Approaches in Gain Sharing and Total Quality* (Tatum, Shaw, & Main, 1996).

This effort was conducted under the support of the Office of the Assistant Secretary of Defense, (Personnel and Readiness), Workforce Quality and Productivity Division.

Point of contact regarding this effort is Dr. B. Charles Tatum, Personnel and Organizational Assessment Department, Code 12, Navy Personnel Research and Development Center, San Diego, CA 92152-7250, (619) 553-7955, DSN 553-7955.

KATHLEEN E. MORENO
Director
Personnel and Organizational Assessment

Summary

Problem and Background

The Federal Government has recognized the need to direct efforts to establish, improve, and maintain quality and productivity. To do this, organizations must devise performance measurement systems that accurately reflect quality, productivity, and general effectiveness. Productivity Gain Sharing and Total Quality Management require that accurate performance indicators be used to measure productivity and quality improvements.

Objective

The purpose of this report is to provide a measurement approach that integrates a wide variety of performance measures. The approach allows the user to generate an index of "total value" that can be used to assess improvements and make gain sharing payouts.

Approach

The methodology assumes the user has established reliable and valid performance indicators (see Nebeker, Tatum, & Wolosin, 1996) for a discussion of how to develop performance indicators). A formula is presented that allows the user to enter their performance indicators into the equation and create an index of "total value." The index is an aggregation of many measures across a wide range of performance dimensions (e.g., productivity, quality, financial performance). The index of "total value" is an expression of the total performance of an organization.

Conclusions

The effectiveness of an organization is more than just the quantity and quality of its products and services. Organizations must develop their resources, keep their stakeholders happy, and invest in their future if they expect to survive in today's economy. Consequently, organizations must attempt to measure intangible dimensions (e.g. customer satisfaction or employee morale) as well as their outputs if they are to receive an accurate picture of performance. The approach presented in this report is one method for assessing organizational performance that includes both tangible and intangible dimensions.

Contents

Introduction

How an organization performs is the product of many different components. One approach for classifying these diverse components of organizational performance is outlined in two reports issued by the Navy Personnel Research and Development Center under the sponsorship of the Office of the Assistant Secretary of Defense (Nebeker, Tatum, & Wolosin, 1996; Tatum, Nebeker, & Wolosin, 1996). In these reports, organizational performance is divided into four basic components—productivity, financial performance, stakeholder relations, and resource development. Each of these four basic components are then subdivided into smaller units of performance (Tatum, Nebeker, & Wolosin, 1996), and examples of specific measures of the performance components are presented (Nebeker, Tatum, & Wolosin, 1996). By examining these two reports, an organization gets a very good idea of how to measure various aspects of their performance, and what is involved in trying to improve their performance and become a more effective organization. The next step in becoming a more effective organization is to develop a systematic approach for combining a set of performance measures and arriving at a number (or index) that summarizes how the organization is performing as a whole. This summary number can then be monitored over time and the organization can chart improvements and target areas in need of improvement. A report by Tatum and Nebeker (1996) illustrates how this index can be computed using a technique known as "performance indexing." This report offers an alternative approach.

The measurement approach proposed here integrates measures of the quality and quantity of production (what is called Output Value [OV]) with measures of the more intangible qualities of an organization (e.g., resource development, stakeholder relation) that relate to its long term success and survival (these measures are referred to collectively as System Value [SV]). With this approach, the productivity of an organization is measured by the familiar ratio of inputs to outputs. However, the *value* (or *quality*) of the outputs and the value of the system as a whole is made an explicit part of the measurement system.

Steps to Measuring Total Organizational Value

Product Value

To begin with, the organization must know its products and services. For each product or service, there exist attributes that define the value or quality of the product or service. To use a simple example, if the product were fruit, the quality attributes might be color, texture, smell, taste (etc.) To use a more complex example, if the product were a computer program used in a missile guidance system, the quality attributes might be the results of various tests of accuracy, functionality, failure rate, ease of use (etc.). Quality attributes are inherent in services as well as products. If an organization delivers a service such as training or repairs, for example, the quality attributes might be course evaluation results, customer satisfaction, or on-time delivery.

When the organization knows its products and services, and can measure the quality attributes in a valid and reliable way (see Nebeker, Tatum & Wolosin, 1996) for a discussion of validity and reliability of measurement), then they are in a position to calculate the **Product Value (PV)** (we will refer to this component as **PV**, but keep in mind that what we are describing applies to services as well as products). **PV** is the weighted sum of all the quality attributes for a single product and is defined mathematically as:

$$PV = \sum_{i=1}^{n} a_i b_i = a_1 b_1 + a_2 b_2 + \ldots + a_n b_n \quad (1)$$

Where,

PV = Product Value

n = The number of attributes

a_i = Standardized measure of the i th product attribute (where i can take on values 1 through n)

b_1 = Weighting factor for attribute at the i th level (where i can take on values 1 through n)

a_1 = The first attribute for the product

a_2 = The second attribute for the product

a_n = The last attribute for the product

b_1 = The weight of the first attribute

b_1 = The weight of the second attribute

b_n = The weight of the last attribute

The above formula simply means that you must take all of the attributes for a given product, weight them by importance, and add them together. The attributes must be standardized in some fashion so that they will all be scaled to the same metric. There are several techniques for standardizing measures, but the most common is the Z score which can be found in any elementary statistics text. The weighting factor (b) is used because the quality attributes are not equally important to the value of the product. For example, if failure rate is the most important quality dimension, and other dimensions such as ease of use or self life are less important, then the weighting factor for failure rate should be larger than the other two. There are many ways to derive these weightings (e.g., the cost of the attribute, principle component analysis, conjoint analysis, expert judgment) but it is beyond the scope of this report to outline these. Nevertheless, one must be aware of the need for deriving weightings if not all attributes are equally important. Of course, if all the attributes are of equal importance, then the b factors can be excluded and **PV** is merely the sum of all the standardized measures for the attributes.

Value of Production

The **Value of Production (VP)** refers to the sum total of all products and services of a given type created by an organization in a certain period of time. For example, if an organization delivers software products, the VP would be the total number of software packages produced in any given period of time. In other words, the VP is the sum of the **Product Values (PVs)**. Mathematically, the VP is defined as:

$$VP = \sum_{j=1}^{m} PV \quad \text{or} \quad m * \overline{PV} \quad (2)$$

Where,

VP = Value of Production
m = The number of products of a given kind
PV = Product Value (computed in equation [1] above)
$\overline{PV}$ = The mean (average) of all Product Values

Output Value

The VP captures the quantity and quality of production for a particular product or service. The **Output Value (OV)** is the weighted sum of different product (service) lines. For example, if an organization not only produced software packages, but also delivered training and repaired computers, these different product/service lines would need to be combined to capture the value of all the outputs of the organization. Combining these different lines is accomplished by computing a weighted sum of the separate VP. Mathematically, the OV is:

$$OV = \sum_{k=1}^{h} VP_k B_k = VP_1 B_1 + VP_2 B_2 + \ldots + VP_h B_h \quad (3)$$

Where,

OV = Output Value
h = The number of different product lines
VP_k = Value of Production of the k th product line (where k can take on values 1 through h)
B_k = Weighting factor for VP of the k th product line (where k can take on values 1 through h)
VP_1 = Value of Production of the first product line
VP_2 = Value of Production of the second product line
VP_h = Value of Production of the last product line
B_1 = The weight of the first product line
B_2 = The weight of the second product line
B_h = The weight of the last product line

The above formula means that you must take all of the separate product lines, weight them, and add them together. The weighting factor (B) is used because it is unlikely that the different product lines are equally important to the organization. For example, if the software product is a much more important line than training or repair, then the weighting factor for the software line should be larger than the other two product/service lines. It is beyond the scope of this report to suggest all of the ways in which these weighting factors can be derived. Nevertheless, it is important to note that, unless all product/service lines are of equal importance, these weighting factors are required. One possible technique for deriving the weights is to determine the proportion of the budget that is accounted for by each product/service line.

System Value

The effectiveness of an organization is more than just the quantity and quality of its products and services (its OV). Organizations must develop their resources, keep their stakeholders happy, and invest in their future if they expect to survive and thrive in today's world. Consequently, organizations must make some attempt to include intangible, long-term dimensions into their performance calculations. For example, organizational reputation, absenteeism, turnover, or employee morale have a long term or intangible link to the "bottom line," but these "soft" indicators of effectiveness must be factored into the equation. **SV** is the sum total of the important intangibles that make up the total performance of an organization. An organization must decide which of these many dimensions to include in the formula, and what weights should be given to these dimensions. In large part these decisions are governed by the nature of the organization. If the organization is a service organization, then overall customer satisfaction and employee morale may be critical to the total performance of the organization. On the other hand, if the organization is involved in a heavy industrial activity, investments in facilities and equipment, or employee health and safety may be the primary concerns. In any event, calculating the SV component follows the same pattern as earlier calculations (i.e., it is the weighted sum of the important system dimensions). Mathematically, SV is:

$$SV = \sum_{q=1}^{p} d_q w_q = d_1 w_1 + d_2 w_2 + \ldots + d_p w_p \qquad (4)$$

Where,

SV = System Value

p = The number of system dimensions (non-product indicators of effectiveness)

d_q = Measure of system value of the q th dimension (where q can take on values 1 through p)

w_q = Weighting factor for the q th dimension (where q can take on values 1 through p)

d_1 = The first system dimension

d_2 = The second system dimension

d_p = The last system dimension

w_1 = The weight of the first system dimension

w_2 = The weight of the second system dimension

w_p = The weight of the last system dimension

As in previous calculations, the weighting factors must be derived in such a way as to reflect the relative importance of each system dimension. Because these dimensions, by their nature, have an uncertain relationship to the outputs of the organization, deriving the weighting factors will be uncertain as well. Over time, empirical relationships between the system dimensions and various measures of output and financial performance can be established. These empirical relationships can then be used to establish the weighting factors. In the short term, however, the organization must rely on the expert judgment of knowledgeable people within the organization to obtain estimates of the weightings.

Total Value

For any given performance period, the **total value (TV)** of the performance of an organization is a combination of its OV and its SV. In other words, the value of all the outputs plus the sum of all the intangibles constitutes the best index of how effectively the organization performed its mission. The final calculation is simply the weighted sum of the OV and the SV, and is expressed in the following mathematical formula:

$$VT = OV \ W_o + SV \ W_s \quad (5)$$

Where,

TV = Total Value
OV = Output Value
W_o = Weighting for Output Value
SV = System Value
W_s = Weighting for System Value

The weighting factors (W_o and W_s) reflect the relative importance of OV and SV and must be derived empirically or through expert judgment. If weighting factors cannot be determined, one (usually not acceptable) alternative is to assume that OV and SV are equally important and drop the weighting factors from the equation.

Using Total Value to Calculate a Productivity Gain Sharing Payout

The **TV** can be calculated for any given performance period and used as the basis for a productivity gain sharing (PGS) payout. In a sense, the TV is an organization's best indicator of the quantity and quality of its products and services during a particular performance period. This indicator also takes into account certain dimensions of performance that reflect its long term health and investment in the future (the SV). To use TV as the basis for PGS payouts, an organization must calculate the TV over several performance periods and establish a baseline (generally, baselines represent several quarters of performance). They must also track the cost of their inputs during the same period. Once a baseline of outputs (TV) and inputs is established, the ratio of these outputs and inputs forms the baseline productivity required for PGS. During some current period, calculating a payout is simply a matter of calculating the TV for the current period, determining the costs of inputs for that same period, and then plugging these numbers, along with the baseline figures, into a PGS formula (see Tatum , Nebeker, & De Young, 1996) for a detailed discussion of how to use a PGS formula).

Conclusions

This approach to measuring the total performance of an organization is similar to other approaches of assessing organizational effectiveness. Felix & Riggs (1983) have described what

they call the Objectives Matrix, and Pritchard and his colleagues (Pritchard, Jones, Roth, Stuebing, & Ekeberg, 1989; Pritchard & Roth, 1991) have developed a methodology called Productivity Measurement Enhancement System (ProMES). Both of these approaches share with the present approach an attempt to combine a set of diverse measures into a single, composite index that reflects the total performance of the organization. Each method, however, has a different emphasis. The Objectives Matrix emphasizes setting goals and builds its approach around making improvements relative to these goals. ProMES also has a goal setting process, but also emphasizes contingencies between performance indicators and overall effectiveness, as well as feedback to organizational members.

The present approach emphasizes integrating the less typical "system" measures (e.g., reputation, morale, absenteeism) with the more traditional "production" measures. The emphasis of the present approach is unique in the literature on measuring organizational effectiveness, and adds a critical dimension to assessing total organizational performance. The information contained in this document, along with the two reports on the typology of organizational effectiveness (Nebeker, Tatum, & Wolosin, 1996; Tatum, Nebeker, & Wolosin, 1996) should provide an excellent foundation for any organization attempting to measure its performance. If an organization is seriously considering PGS, these reports on measurement should be required reading.

References

Felix, G. H., & Riggs, J. L. (1983). Productivity measurement by objectives. *National Productivity Review, 2*(4), 386-393.

**Nebeker, D. M., Tatum, B. C., & Wolosin, D. G. (1996). *Examples of white collar measurement using a typology of organizational effectiveness* (NPRDC-TN-96-30). San Diego: Navy Personnel Research and Development Center.

Pritchard, R. D., & Roth, P. G. (1991). Accounting for nonlinear utility functions in composite measures of productivity and performance. *Organizational Behavior and Human Decision Processes, 50*, 341-359

Pritchard, R. D., Jones, S. D., Roth, P. L., Stuebing, K. K., & Ekeberg, S. E. (1989). The evaluation of an integrated approach to measuring organizational productivity. *Personnel Psychology, 42*, 69-115.

*Tatum, B. C., Nebeker, D. M., & De Young, P. H. (1996). *Using performance indexing to measure organizational gains in a white collar environment* (NPRDC-TN-96-27). San Diego: Navy Personnel Research and Development Center.

*Tatum, B. C., Shaw, K. N., & Main, R. E. (1996). *Integrating measurement approaches in gain sharing and total quality* (NPRDC-TN-96-31). San Diego: Navy Personnel Research and Development Center.

Tatum, B. C., Nebeker, D. M., & Wolosin, D. G. (1996). *A typology of organizational effectiveness* (NPRDC-TN-96-28). San Diego: Navy Personnel Research and Development Center.

---

*Found in Foreword.

**Found in Foreword and Summary of this report.

Distribution List

Office of the Under Secretary of Defense (P&R)
Defense Technical Information Center (DTIC) (4)